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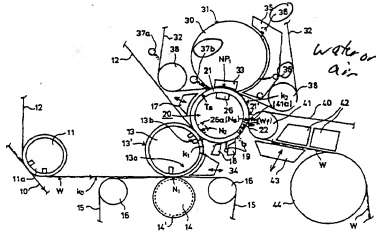
Smooth roll

(54) Title: PRESS SECTION IN A PAPER MACHINE IN WHICH AN EXTENDED-NIP PRESS IS EMPLOYED



Water or air

1/9 - hot water or steam

2 doctors

(57) Abstract

The invention concerns a press section in a paper machine, which press section comprises a compact combination of rolls, which rolls form a number of press nips with one another, which nips remove water out of the paper web (W). Between said nips, the paper web (W) has a closed draw supported by a press fabric or by a roll face. The press section includes a centre roll (20; 20A), in connection with which there are at least two press nips (N_2, NP_1; N_2, NP_{11}). The last nip placed in connection with the centre roll (20; 20A) is an extended nip (NP_1; NP_{11}). The centre roll (20; 20A) is a roll provided with circulation of heating medium ($F_{in} \rightarrow F_{out}$) and with a heated outer mantle. The outer face (21') of the mantle (21) of the centre roll (20; 20A) is heated by means of circulation of medium ($F_{in} \rightarrow F_{out}$) to such a temperature level (T_S) that the dewatering of the paper web (W) in the nips (N_2, NP_1; N_2, NP_{11}) placed in connection with the centre roll (20; 20A), in particular in said extended nip (NP_1; NP_{11}), is intensified substantially. The invention can also be accomplished in an environment in which there are two or more separate press nips (NP_{12}, NP_{22}), of which nips at least the last nip is an extended nip (Figs. 7 and 7A).

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Press section in a paper machine in which an extended-nip press is employed

The invention concerns a press section in a paper machine, which press section comprises a compact combination of rolls, which rolls form a number of press nips with one another, which nips remove water out of the paper web and between which nips the paper web has a closed draw supported by a press fabric or by a roll face, and which press section includes a centre roll, in connection with which there are at least two press nips.

Further, the invention concerns a press section in a paper machine, which press section comprises two or more separate press nips, of which nips at least the last nip is an extended nip, and between which press nips the paper web has a closed draw supported by a roll face or a press fabric.

From the prior art, various closed and compact press sections are known, in which there are several press nips formed between press rolls, between which nips the web has a closed draw. Of these press sections should be mentioned the press sections marketed by the applicant with the product names "Sym-Press II"™ and "Sym-Press O"™, in which presses there are three successive roll nips in connection with a compact combination of rolls. If necessary, these press sections can be provided with a fourth, separate press nip.

With constantly increasing running speeds of paper machines, the press section has become a bottle-neck in increasing the speeds. This comes above all from the fact that the times of dwell of the web to be pressed remain insufficiently short in short roll nips, and, on the other hand, the compression pressure cannot be increased infinitely without destruction of the structure of the web. To a constantly increasing extent, so-called extended-nip presses have been introduced, in which the length of

the press nip zone is (5...10) x the length of a roll nip zone. With respect to the prior art concerning press sections that make use of various extended nips and equivalent, reference is made, by way of example, to the following *US Patents: 4,561,939; 4,704,192; 4,915,790,* and *5,120,399,* to the *EP Patent Applications 0,401,190 A3* and *0,608,533 A1*, and to the *DE Patent Application 4,321,405 A1* and to the *EP Patent 0,337,973*.

Extended nips have also been employed in closed and compact press sections similar to those mentioned above, in which respect reference is made to the paper *Wochenblatt für Papierfabrikation 5, 1988; A. Meinecke und K. Steiner: "Zum Einsatz von Schuhpressen bei Schreib- und Druckpapieren"*, Abb 16, page 178.

Further, it is known from the prior art to use various heating devices in press sections, such as steam boxes, infrared or induction heaters, by whose means the temperature of the paper web is raised so that the dewatering is enhanced in the roll nips. This enhanced dewatering results mainly, as is well known, from the lowered viscosity of the water present in the fibre mesh of the web and from increased elasticity of the web, arising from the raised temperature.

With respect to the prior art related to the present invention, reference is also made to the applicant's *FI Patent Applications 870308* and *870309*. In said FI Pat. Appl. *870308* a method and a device are described for separating the web from a smooth-faced press roll on an unsupported draw, in which method the temperature of said press roll is regulated, and by means of this regulation the adhesion between the roll face and the paper web to be separated is affected, and thereby the angle of separation and/or the tension of separation of the paper web is/are set within an optimal range. In said FI Pat. Appl. *870309* a method and a device are described, in which the web is separated from a smooth roll face as an unsupported draw, and in the area of the separation point the web is subjected to a momentary and local induction heating effect from outside the smooth-faced press roll, by means of which heating effect the water placed between the web and the roll face is heated, preferably

vaporized, locally in the area of the separation point so as to separate the web from the roll face.

In this connection, further, reference is made to the applicant's *FI Patent 92,941*, in which a method is described in which a transfer zone is employed, over which a press fabric or a particular transfer fabric is passed so as to accomplish a closed draw of the web, and which transfer zone and said fabric are arranged to form a transfer nip or a transfer zone with said roll face, and in which method, at the transfer point, the level of the temperature of said roll face and/or of the web is set or regulated. In the method defined above in the *FI Patent 92,941*, it is novel that, in the method, the transfer zone is subjected to a vacuum and that at the transfer point the level of temperature of said roll face and/or of the web is set or adjusted high enough so that the pressure, corresponding to said temperature, of saturated vapour of the water present in connection with the web and the roll face is substantially equal to, or higher than, the pressure that has been made to be present in said transfer zone, which pressure is lower than the atmospheric pressure.

An object of the present invention is also to be able to make use of the methods and the web separation and transfer arrangements described in said *FI Patent Applications 870308* and *870309* and in the *FI Patent 92,941* synergically in connection with the present invention.

Also known from the prior art in the dewatering of a paper web, there are the hot-pressing devices proper, in which so-called impulse drying is used. In this mode of drying the web is passed into connection with a face, usually a roll face, whose surface temperature is of an order of 150...500°C. It is also known from the prior art to use a combination of impulse drying and extended-nip zone, with respect to which reference is made to the International Patent *WO 95/21962* of Beloit Technologies Inc. (date of publishing August 17, 1995). In said publication, the paper web is pressed against a roll, which has been heated to about 150...500°C, in an extended-nip zone. The heating of the roll is carried out in particular by means of induction heating, and the purpose of the press device is to increase the dry solids

content of the web by about 10...15 percentage units and to reach dry solids contents as high as up to 65...75 %.

From the prior art, also rolls are known which are heated in various ways and which are meant for use in press sections and finishing devices of paper machines, such as calenders, with respect to which rolls reference is made, by way of example, to the applicant's FI Laid-open Publications Nos. *87,485, 88,419, 89,087, 91,297, 92,733,* and to the FI Patent Applications Nos. *924754, 925634,* and *930349.*

The object of the present invention is, with the prior art mentioned above as the starting point, further development of press sections of paper machines, in particular of compact closed press sections, so that increased running speeds of paper machines are permitted owing to a substantially enhanced dewatering capacity of the press section. It should be emphasized in this connection that the press section in accordance with the present invention is not supposed to operate as said hot press proper and that impulse drying is not applied in the invention.

An object of the present invention is to provide a press section in which the operation of the press can be enhanced substantially by, in particular, using inexpensive steam energy in order to increase the dewatering capacity, and in the invention the use of expensive electric energy and, thus, also of induction heating, is supposed to be avoided, which induction heating is applied primarily in the press section in accordance with said publication *WO 95/21962.*

An object of the present invention is to provide a press section after which the dry solids content of the web is, depending on the paper grade, on its raw-material and on the speed of the machine, of an order of 50...58 %.

It is a further object of the invention to provide a press section in which the cross-direction compression-pressure profile of the web and, owing to that, the cross-direction profile of dry solids content of the web can be regulated both in the machine direction and in the cross direction.

In view of achieving the objectives stated above and those that will come out later, a first embodiment of the invention is mainly characterized in that the last nip placed in connection with said centre roll is an extended nip, that said centre roll is a roll provided with circulation of heating medium and with a heated outer mantle, and that the outer face of the mantle of the centre roll is heated by means of said circulation of medium to such a temperature level that the dewatering of the paper web in the nips placed in connection with the centre roll, in particular in said extended nip, is intensified substantially.

A second embodiment of the press section in accordance with the invention is mainly characterized in that the press roll in the last extended nip is a press roll provided with circulation of heating medium and with a heated outer mantle, and that the outer face of the mantle of said press roll is heated by means of said circulation of medium to such a temperature level that the dewatering of the paper web is intensified substantially in the extended nip placed in connection with said press roll.

In the invention, by means of extended-nip pressing and by means of a heated press roll operating in its connection, in particular by means of the centre roll of a closed press section, effects synergic with one another are obtained. These effects are based on the fact that, in a press section in accordance with the invention, good thermal conductivity is obtained between the paper web that is pressed and the heated roll face, and in such a case the wet paper web can be made to bind an abundance of energy. Thus, the temperature of the paper web that is pressed can be raised sufficiently, and this raised temperature level will be effective in the extended nip for a sufficiently long period of time and over a sufficiently long distance. In this way the operation of the press is intensified substantially. However, in the present invention, hot pressing and impulse drying proper are not concerned, for the heated roll face is, preferably, as a rule, heated to a temperature lower than 100°C, as a rule to a temperature in the range of 60...95°C. In exceptional cases, it is also possible to use a roll face which has been heated to a temperature slightly higher than 100°C, in particular when, besides the circulation of a heating medium in the

hot roll, other, outside devices for heating the web are used, such as a steam box, hot-water jets, and/or equivalent.

In a press in accordance with the invention, preferably such a heated centre roll is used as is provided with a mantle with axial bores, in which mantle hot water, oil or water steam is circulated. In this way it is possible to make use of relatively inexpensive steam energy, for example, by means of a heat exchanger, and it is unnecessary to apply induction heating and to consume expensive electric energy.

In the present invention, the surface temperature of the centre roll or of a corresponding smooth-faced roll in a separate nip can be regulated or set so that separation of the paper web from said centre roll is facilitated, for example, when methods and arrangements that have been described in said *FI Patent Applications 870308* and *870309* and in said *FI Patent 92,941* are utilized synergically.

Even though, above and in the following, the press section of a paper machine and a paper web are spoken of, it is to be emphasized that the scope of the present invention also includes press sections meant for dewatering of board webs, for which press sections the invention is well suitable.

In the following, the invention will be described in detail with reference to some preferred exemplifying embodiments of the invention illustrated in the figures in the accompanying drawing, the invention being in no way strictly confined to the details of said embodiments.

Figure 1 is a schematic side view of the invention as applied in a three-nip press section of the applicant's "Sym-Press II"™ type.

Figure 2 is a schematic illustration of an embodiment of the invention in a press section of the "Twinver"™ type.

Figure 3 shows a modification of the press section as shown in Fig. 2, wherein a third, separate press nip is employed additionally.

Figure 4 shows a press section of the applicant's "Sym-Press O"™ type as an environment of application of the invention.

Figure 5 shows such a modification of the press section as shown in Fig. 1 in which an extended nip is used as an additional, separate fourth press zone.

Figure 6 shows such a press section, mainly of the "Sym-Press II"™ or "Twinver"™ type, in which there is an additional extended nip as the first press nip.

Figure 7 shows a particular embodiment of the invention in which two successive separate extended-nip zones are employed.

Figure 7A shows such a modification of the rear end of the press section as shown in Fig. 7 in which the last extended nip is preceded by a pre-roll nip which enhances the web heating effect.

Figure 8 is a central axial sectional view of a variable-crown hot roll that can be applied in the invention.

Figure 8A is a vertical sectional view taken along the line A—A in Fig. 8.

Figure 8B is a vertical sectional view taken along the line B—B in Fig. 8.

Figure 8C is a horizontal sectional view taken along the line C—C in Fig. 8.

Figure 9 is a central axial sectional view of a non-variable-crown, rigid hot roll of tubular type that can be applied in the invention.

Figure 9A is a vertical sectional view taken along the line A—A in Fig. 9.

Figure 9B is a vertical sectional view taken along the line B—B in Fig. 9.

Figure 9C is a horizontal sectional view taken along the line C—C in Fig. 9.

The press section in accordance with the present invention that is shown in Fig. 1 has a basic geometry of a press section marketed by the applicant with the trade mark "Sym-Press II", in which there are three successive dewatering press nips N_1, N_2 and NP_1. Differing from a normal "Sym-Press II" press section, the last nip NP_1 is expressly an extended nip, whose extended-nip zone has a length of an order of 100...300 mm in the machine direction. The length of the extended-nip zone NP_1 in the machine direction is about (3...10) x the corresponding length of the roll nips N_1 and N_2. The same ratio, of course, also applies to the press times in the individual nips. Also, in wider machines ($\approx \geq$ 4.5 m), in a press section in accordance with the invention, as the centre roll expressly a particular variable-crown hot roll 20 is employed, of whose construction one preferred exemplifying embodiment will be described later in more detail mainly with reference to Figs. 8, 8A, 8B and 8C. In narrower machines (width $\approx \leq$ 4.5 m), as a hot roll, it is also possible to use a roll with no crown variation, of which roll an example is the hot roll 20A, which is illustrated in Figs. 9, 9A, 9B and 9C and which will be described later.

As is shown in Fig. 1, the paper web W is separated by means of the suction zone 11a of the pick-up roll 11 from the forming wire 10 and passed on the lower face of the pick-up felt 12 into the first roll nip N_1. The first roll nip N_1 is a nip with two felts, and through said nip, besides the pick-up felt 12, also a water-receiving lower felt 15 runs, which is guided by guide rolls 16. The lower roll in the press nip N_1 is a press roll 14 provided with a hollow face, for example a grooved face 14', and the upper roll is a press-suction roll 13, which includes two successive suction zones 13a and 13b. In the nip N_1 the draining of water takes place in two directions into the felts 12 and 15 through both faces of the web. The press-suction roll 13 is provided with a perforated mantle 13', and on its first suction zone 13a the pick-up felt 12 and the web W placed on its outer face are curved into the second roll nip N_2, at whose press zone there is the second suction zone 13b, in which preferably

a higher vacuum is employed than in the former zone 13a. The second roll nip N_2 is formed between said press-suction roll 13 and a particular heated variable-crown centre roll 20, which has been arranged in accordance with the invention. In connection with the suction zone 13a of the suction roll 13, in the vicinity of the outer face of the web W, there is a steam box 34, by whose means the temperature level of the web is raised before the second roll nip N_2 and before the web enters into connection with the heated face 21' of the mantle 21 of the hot roll 20.

After the roll nip N_2 the web W follows the smooth face 21' of the centre roll 20 into the third press nip, which is, according to the invention, expressly an extended nip NP_1. Through the extended-nip zone NP_1 a water-receiving press felt 32 runs, which is guided by guide rolls 38. The extended-nip zone NP_1 is formed, together with the heated centre roll 20, by the extended-nip roll 30, which is, for example, an extended-nip roll provided with a hose mantle 31, in which there is a press shoe 33 at the press zone NP_1, and it is possible that the pressure effect of said press shoe can be profiled in the cross direction. As the extended-nip roll 30 in the extended nip NP_1 as shown in Fig. 1, favourably an extended-nip roll of the type marketed by the applicant with the trade mark "Sym-Belt S"™ is used, in which roll the glide-belt mantle 31 is attached to tightly journalled end rings. With respect to the details of the construction and the operation of a "Sym-Belt S" roll, reference is made to the applicant's following patents: *FI-70,952, EP-0,345,500,* and *EP-0,527,881*.

At the extended-nip zone NP_1, inside the mantle 21 of the centre roll 20, there is a series of loading-glide shoes 26, and the cross-direction pressure profile of the nip zone NP_1 can be controlled by regulating the loading pressures of said shoes. Also at the nip N_2, it is possible to use a second series of glide shoes 26a, corresponding to said series of glide shoes 26, by means of which glide shoes 26a it is possible to regulate the cross-direction compression-pressure profile of the roll nip N_2 and by means of which glide shoes the flattening and deflection of the mantle of the centre roll 20, produced by the roll nip N_2, can be controlled.

Between the nips N_2 and NP_1 the paper web W adheres to the smooth face 21' of the centre roll 20 so that the web W has a free outer face, in connection with which a steam box or an infrared and/or induction heating device 17 has been fitted. Preferably a steam box or an infrared heater 17 is used, whose heating effect is applied primarily to the free outer face of the web W, whereas the inner face of the web W is heated by means of the heating effect of the mantle 21 of the hot roll 20 in a way that will come out later.

After the extended-nip zone NP_1 the web W follows the smooth face 21' of the centre roll 21, from which the web W is separated preferably as a short free draw W_f and is transferred on a suction zone onto the drying wire 40 of the first cylinder group in the dryer section following after the press section, which drying wire 40 circulates around a guide roll 41 or a vacuum roll. After the guide roll or vacuum roll 41, against the free outer face of the web W, an infrared and/or steam heater 43 has been fitted, opposite to which heater blow-suction boxes 42 operate, which keep the web W on the lower face of the drying wire 40 and, at the same time, intensify the penetration of the heating effect of the device 43 into the web W. After this the web W is passed on the drying wire 40 over the first drying cylinder 44 or over an equivalent lead-in cylinder and further as a closed draw through the first wire group in the dryer section.

In Fig. 1, moreover, at the extended nip NP_1, cooling-water jet devices 37a and 37b for the press felt 32 are shown, and after the extended nip NP_1 a water drain trough 35, which is fitted in connection with the mantle 31 of the hose roll 30 and in connection with which there are wash and/or cooling jet devices 36 for the extended-nip roll mantle 31, which jet devices are based on spraying of water or air. The outer face of the glide-belt mantle 31 of the extended-nip roll 30 is either smooth or hollow, for example grooved. By means of said cooling jet devices 36,37a,37b, risk of damage arising from increased temperature of the mantle 21 of the hot roll 20, resulting from quick stopping of the press section, is prevented. Moreover, Fig. 1 shows doctors 18 on the free lower sector of the centre roll 20, and in connection with the blades of said doctors there are lubricating jet devices 19, which are based

on spraying of hot water or steam, whereby it is possible to contribute to raising the temperature level T_S of the outer face 21' of the mantle 21 of the roll 20 and to intensify the cleaning of the roll nip.

According to the invention, the centre roll 20 is provided with internal heating, which is accomplished, for example, by means of circulating heated water or oil passed into the bores 22 in the mantle 21 of the centre roll, which will be described in more detail later in relation to Figs. 8...8C and 9...9C. The web W, which was pressed in the first roll nip N_1 and whose dry solids content is of an order of $k_1 \approx$ 25...40 %, obtains a very good contact with the smooth outer face 21' of the mantle 21 of the centre roll 20 in the sharp roll nip N_2. This is why in the nip N_2, and after it in the extended-nip zone NP_1, a particularly efficient transfer of heat is accomplished from the mantle 21 of the hot centre roll 20 into the web W. Between the nips N_2 and NP_1, the web W is heated from the side of its outside face by means of a steam box or, in exceptional cases, by means of an infrared heater 17. As a coating on the mantle 21 of the centre roll 20, for example, a suitable ceramic coating or a tungsten-carbide metal alloy is used. Owing to efficient transfer of heat, there is a risk of cracking of said coating because of a thermal shock. In order to avoid this, it is preferable to restrict the flow of heat from the interior of the roll mantle 21 to the outer face 21' so that the temperature T_f of the heating medium is chosen just as low as $T_f \approx 110°C$, and, if necessary, additional thermal energy is passed to the face of the mantle by means of the hot-water/steam lubrication jets 19 of the doctors 18 and/or by means of a heater 17. In this way the temperature T_S of the outer face 21' of the mantle 21 of the heated centre roll 20 can be made sufficiently high. As a rule, said temperature T_S is chosen in the range of $T_S \approx 60...$ 95°C, preferably $T_S \approx 70...85$ °C, with which temperature a particularly efficient dewatering is accomplished in the extended nip NP_1. In an exceptional case, the temperature level T_S can be raised slightly above 100°C, in particular when auxiliary heating devices are used in connection with the roll face, such as water jets 19 and/or a steam box 17. As is well known, by means of a raised temperature level the viscosity of the water present in the fibre mesh in the web is lowered and the elastic properties of the fibre mesh are altered so as to intensify the dewatering. As this

effect is produced expressly in the extended nip NP_1, it has an adequate time of effect in view of intensifying the dewatering. The relatively wet web placed in connection with the outer face 21' of the hot roll 20 can be made to bind an abundance of energy, and the transfer of said energy into the web W is enhanced by a good heat transfer contact and by a sufficiently large face of heat transfer between the web W and the roll face 21'.

In a press section as shown in Fig. 1, the linear loads in the roll nips N_1 and N_2 are, as a rule, chosen in a range of $N_1 \approx 50...100$ kN/m and $N_2 \approx 50...120$ kN/m. In the extended nip NP_1 the distribution of pressure in the machine direction and in the cross direction can be regulated in a way in itself known. The average linear load in the extended nip NP_1 is, as a rule, chosen in a range of $NP_1 \approx 300...1200$ kN/m.

In a press section as shown in Fig. 1, when the dry solids content k_1 of the web before the nip N_2 is typically $k_1 \approx 25...40$ %, the dry solids content k_2 after the extended nip is typically $k_2 \approx 50...58$ %. The dry solids content k_0 of the web W before the first nip N_1;NP_{10};NP_{12} in the press section is typically $k_0 \approx 13...23$ %.

The enhanced dewatering resulting from the present invention can be realized as a higher speed of the paper machine and/or as an increased proportion of dewatering taking place by pressing, in relation to the dewatering by evaporation, which is favourable from the point of view of energy economy. The thermal capacity P_H passed to the paper web W through, and in connection with, the heated centre roll 20 is, as a rule, chosen, per metre of width of the machine, in the range of $P_H \approx 100...300$ kW/m, so that, in a machine of a width of 10 metres, the total thermal capacity P_{HT} concerned is $P_{HT} \approx 1...3$ MW.

Fig. 2 shows a press section of the "Twinver" type as an environment of application of the invention, which press section differs from that shown in Fig. 1 in the respect that there is no first roll nip in connection with the pick-up felt 12 and the suction roll 13A, but the first nip N_{10} in the press section is formed between said press suction roll 13A and the heated centre roll 20 arranged in accordance with the

invention. The second press zone in Fig. 2 is an extended-nip press NP_1, in the way illustrated in Fig. 1. As an addition in relation to Fig. 1, Fig. 2 shows the guide and tensioning rolls 12a and the conditioning devices 12b of the pick-up felt 12 as well as the guide, alignment and tensioning rolls 32a and the conditioning devices 32b of the water-receiving press felt 32 of the extended nip NP_1. Further, Fig. 2 shows two contact drying cylinders 44 in the first dryer group and a reversing suction roll 45 provided with a hollow-faced mantle 45' subjected to a vacuum. Since, compared with Fig. 1, the press section shown in Fig. 2 lacks the first two-felt roll nip N_1, the press section shown in Fig. 2 is suitable for lower machine speeds and/or for thinner paper grades than the press section shown in Fig. 1.

Fig. 3 shows such a modification of the press section shown in Fig. 2 in which, besides the roll nip N_{10} and the extended nip NP_1, there is a separate roll nip N_{20}. The paper web W is separated from the smooth face 21' of the heated centre roll 20 as a short free draw W_{f1} by means of the transfer roll 51A and is passed, with the aid of the suction zone 51a of the transfer suction roll 51, onto the lower felt 50, on whose top face the web W is passed into the second roll nip N_{20}. This nip N_{20} is formed between a large-diameter smooth-faced 55' upper roll 55 and a hollow-faced 56' lower press roll 56. The lower felt 50 is guided by tensioning, alignment and guide rolls 53 and conditioned by the devices 54. Before the roll nip N_{20} there is a suction box 52, and after the roll nip N_{20} the web W follows the smooth face 55' of the upper roll 55, from which it is separated by means of the transfer roll 46 as a short free draw W_{f2} and transferred onto the drying wire 40. In connection with the smooth-faced 55' upper roll 55 of the nip N_{20} there is a cleaning doctor 57 and a broke conveyor 58. In other respects the construction and the operation of the press section shown in Fig. 3 is similar to those described in relation to Figs. 1 and 2.

Fig. 4 shows a press section of the type "Sym-Press O" as an environment of application of the invention, which press section differs from that shown in Fig. 1 in the respect that, in Fig. 4, the press suction roll 13B placed as the upper roll of the two-felt 12,15 roll nip N_1 does not form a press nip with the heated centre roll 20, but after the suction zone 13a of the press suction roll 13B the web W and the

pick-up felt 12 have an almost vertical free run onto the heated centre roll 20, in connection with which there is the second roll nip N_2. This nip N_2 is formed by a hollow-faced 60' press roll 60. In the other respects the construction and the operation of the press section shown in Fig. 4 are similar to those shown in Fig. 1.

Fig. 5 shows such a press section of the "Sym-Press II" type intended for particularly high-speed paper machines and/or for thicker paper grades as is provided with a separate fourth nip, which is expressly an extended nip NP_2. Thus, the construction and the operation of the press section shown in Fig. 5 are similar to those described above in relation to Fig. 3, except that the separate roll nip N_{20} shown in Fig. 3 has been substituted for by an extended nip NP_2, whose lower roll is an extended-nip roll 56A provided with a hose mantle 56a and including a series of loading shoes 59. The upper roll of the extended nip NP_2 is a smooth-faced 55a press roll 55A, from which the web W is passed as a free draw W_{f2} onto the transfer roll 46 and further onto the drying wire 40 in the way described above. If it is desired, in the extended nip NP_2, to use the enhancement of dewatering in accordance with the invention, achieved by means of raised temperature, similarly to the first extended nip NP_1 and to the roll nip N_2, the upper roll 55A of the latter extended nip NP_2 can be substituted for by a roll provided with a heated mantle, which is represented in Fig. 5 by the reference numeral 20 in brackets.

Fig. 6 shows an embodiment of the invention in which there is a closed press section of the type "Sym-Press II" or "Twinver", which is preceded by an extended nip NP_{10} as the first dewatering nip. Through the extended nip NP_{10} the pick-up felt 12A runs as the upper fabric and the lower felt 15A as the lower fabric, said lower felt 15A carrying the web W onto the suction roll 13A. In connection with the suction roll 13A, if necessary, a roll nip can be arranged, which is represented by the reference denotation N_1 in brackets and by the lower press roll 14a drawn with a dashed line. The first extended nip NP_{10} is formed by the extended-nip roll 61, which is placed inside the lower-felt loop 15A, which is provided with a smooth-faced or hollow-faced hose mantle 61', and in which there is a series of press-glide shoes 69. The lower roll in the first extended nip NP_{10} is a hollow-faced 62' press

roll 62, which can be arranged as a variable-crown roll if necessary. In the first extended-nip NP_{10}, a substantial proportion of the dewatering is carried out so that in the following nips N_1,N_2 and NP_{11} a particularly high dry solids content is achieved even at high web W speeds.

In the embodiments of the invention described above and in those that will be described later, the temperature of the cylinder of the centre roll 20 can be regulated or set also in view of the objective that the separation of the paper web from the centre roll 20 or from the press rolls 20B of the extended nips shown in Figs. 7 and 7A can be facilitated or optimized. In this connection, it is possible to use the methods and devices described in the *applicant's said FI Patent Applications Nos. 870308* and *870309*. Further, it is possible to modify, for example the embodiment shown in Fig. 1 so that, in the position of the roll 41, a transfer suction roll is employed, which is provided with a suction zone 41a and which is arranged to form a transfer nip N_S with low load with the mantle 22 of the centre roll 20. In such a case, the web is provided with a fully closed draw onto the drying wire 40 without an open draw W_f. In respect of the arrangement of this transfer method, reference is made to the *applicant's said FI Patent No. 92,941*.

Fig. 7 shows a press section in accordance with a second particular embodiment of the invention, which differs substantially from those described above and in which two separate extended-nip zones NP_{12} and NP_{22} are used. After the first extended nip NP_{12} the web W follows the lower fabric, which is preferably a smooth-faced transfer belt 15B substantially not receiving water or a water-receiving press felt. The transfer of the web W onto the lower fabric 15B can be aided by means of a suction device 15c, such as a suction shoe or a suction roll. On the transfer belt 15B or equivalent the web W is transferred onto the upper felt 65 of the second extended nip NP_{22} by means of the suction zone 64a of the transfer suction roll 64, after which the web W is passed on the lower face of the upper felt 65 into the second extended-nip zone NP_{22}. The keeping of the web W on the lower face of the upper felt 65 is ensured by means of vacuum boxes or blow-suction boxes 68. The upper roll of this extended-nip zone NP_{22} is an extended-nip roll 63 provided with a hose

mantle 63', which roll 63 includes a series of press-glide shoes 69. The lower roll in the second extended-nip zone NP_{22} is, in accordance with the second particular embodiment of the invention, a heated roll 20B, whose mantle can be arranged to be heated similarly to the mantles of the centre rolls 20;20A in the press sections described above. The temperature level of the roll 20B is, as a rule, raised to a range of $T_S \approx 65...95°C$, preferably $T_S \approx 70...85°C$, whereby the dewatering is promoted and intensified in the latter extended nip NP_{22} formed by the heated roll 20B.

Fig. 7A shows a modification of the embodiment of the rear end of the press section shown in Fig. 7. In connection with the smooth-faced lower press roll 20B heated in accordance with the invention, before the second extended-nip zone NP_{22}, a pre-roll nip N_{02} has been arranged. The pre-nip N_{02} is formed between said heated press roll 20B and the hollow-faced 81 press roll 80. The diameter of the press roll 80 is preferably just about one half of the diameter of the heated press roll 20B. By means of this pre-nip N_{02}, the web W heating effect is intensified. Moreover, the pre-nip N_{02} removes water into the upper felt 65. It should be emphasized that the embodiment of the invention shown in Figs. 7 and 7A is clearly separate and different from the embodiments shown in Figs. 1 to 6, in particular in the respect that, in Figs. 7 and 7A, an expressly heated centre roll 20 is not shown in a closed and compact press roll geometry in which there is at least one extended-nip zone. However, a common feature is synergic joint operation of an internally heated press roll 20B and of an extended-nip zone NP_{22} placed in its connection and of a possible pre-nip N_{02}, if any, so as to intensify the dewatering by making use of the sufficiently long dwell times of the web W and of the sufficiently high levels of water temperature in the fibre mesh in the web, which are accomplished in the extended nip N_{22}.

In the following, with reference to Figs. 8,8A,8B and 8C, a preferred exemplifying embodiment of a heated centre roll 20 for use in the invention will be described. The variable-crown centre roll 20 comprises a static central axle 23, which is supported from the axle journals 23a and 23b of the central axle 23 by means of bearings 24a and 24b which permit bending and which bearings are attached to the bearing supports (not shown) of the roll 20. Revolving on the static central axle 23, a

cylindrical roll mantle 21 is mounted, which has a smooth cylindrical outer face 21' and a corresponding inner face 21". In the central axle 23, at the extended nip NP_1, there is a series of loading glide shoes 26, by whose means regulation of the loading backup force and bending of the mantle 21 is produced in order to control the cross-direction pressure profile in the nip NP_1. The series of glide shoes 26 is loaded by means of separately adjustable fluid pressures $p_1 \ldots p_n \approx 1.5 \ldots 20$ Mpa passed into the cylinder spaces 27 through the pipes 28. The roll 20 mantle 21 is attached to the ends 21a and 21b, by whose means the roll 20 is mounted so that it revolves around and on the axle 23. The roll 20 is mechanically driven, and for this purpose, in connection with one end 21a, there is a tooth rim 73, which is driven by the shaft 71 of the drive motor 70 by means of a gear wheel 72. At the roll end opposite to the drive gear 70...73 of the roll 20, a static distributor coupling 25 for the circulation flow F_{in}—F_{out} of the heating medium is fitted. The distributor coupling 25 is fitted around the revolving axle journal 21b, and its inside annular ducts 22b and 22c are defined by seals 25a.

As is shown in Figs. 8 to 8C, in the mantle 21 of the hot roll 20 there is a series of axial flow ducts 22, which are connected by means of radial ducts 22a with the annular spaces 22b and 22c in the coupling. In the roll-mantle 21 end opposite to the coupling 25, adjacent flow ducts 22' and 22" are interconnected by means of end ducts 22d so that the flow $F_{1\,in}$ of the heating medium passes along the ducts 21' and is reversed in the end duct 22d through the adjacent duct 22" as a return flow $F_{1\,out}$ and returns into the annular space 22c and flows out of said space to the source (not shown) of heating medium. As is shown in Fig. 8C, the end ducts 22d are defined by the end walls 22e. In this way a relatively uniform distribution of the temperature T_S in the outer face 21' of the roll mantle 21 is obtained. A flow distribution coupling 25 is provided at one end of the variable-crown hot roll 20 only, because the roll 20 must be provided with a mechanical drive 70...73. In Fig. 8B, a second series of loading shoes 26a is also shown, by means of dashed lines, which series is placed at the roll nip N_1 in order to control its cross-direction profile of linear load. The series 26;26a of loading shoes can be either hydrostatic or hydrodynamic, or they may operate by means of a combination of same. The

temperature T_f of the heating medium circulating in the flow ducts 22, such as oil, water or water steam, is, as a rule, chosen in the range of $T_f \approx 70...180°C$, preferably $T_f \approx 90...140°C$.

In Figs. 9,9A,9B and 9C, an alternative embodiment is shown of a hot roll 20A applicable in the invention. The hot roll 20A is a rigid roll of tubular type, which is not provided with crown variation. The hot roll 20A can be used, for example, in narrower machines and/or in positions in which the nip load is not particularly high. The roll 20A comprises a cylindrical roll mantle 210, whose outer face is a smooth or hollow face 211 and which has an inner face 212. The roll mantle 210 is attached to end pieces 213 and 214, which include the fixed axle journals 231 and 232 of the roll 20A. The roll 20A is mounted on bearing supports 241 and 242 so that it revolves on the bearings 233 and 234, and it is driven by means of a drive gear 70 through the shaft 71. At the roll 20A end opposite to the drive gear 70, there are coupling arrangements for the circulation flow F_{out}—F_{in} of the heating medium. The roll 20A mantle 210 is provided with axial flow ducts 220, whose inlet ducts 220' communicate through radial ducts 221 with a central flow duct 223 placed in the axle journal 232. At the end of the axle journal 232 there is a flow distribution coupling 250, from which the inlet flow F_{in} of the heating medium passes through the duct 226 first into the duct 223, is from there divided into radial ducts 221 and further into the axial inlet ducts 220' in the roll mantle 210 (Fig. 9C) to constitute inlet flows $F_{1\ in}$, which pass through the end ducts 227 defined by the walls 228 into the adjacent ducts 220" to constitute return flows $F_{1\ out}$. These return flows $F_{1\ out}$ are passed by means of radial ducts 222 into axial ducts 224 and from there further into the annular duct 225 in the end of the distribution coupling 250 and through the ducts 251 and 252 placed in connection with said annular duct 225 to make a return flow F_{out} of the heating medium.

Also many other, different embodiments of the heated centre roll 20;20A;20B are possible when the invention is applied. With respect to these, reference is made, by way of example, to the applicant's *FI Patent No. 89,085 and FI Patent Application No. 882312*.

In the following, the patent claims will be given, and the various details of the invention may show variation within the scope of the inventive idea defined in said claims and differ from what has been stated above by way of example only.

Claims

1. A press section in a paper machine, which press section comprises a compact combination of rolls, which rolls form a number of press nips with one another, which nips remove water out of the paper web (W) and between which nips the paper web (W) has a closed draw supported by a press fabric or by a roll face, and which press section includes a centre roll (20;20A), in connection with which there are at least two press nips (N_2,NP_1;N_2,NP_{11}), **characterized** in that the last nip placed in connection with said centre roll (20;20A) is an extended nip (NP_1;NP_{11}), that said centre roll (20;20A) is a roll provided with circulation of heating medium ($F_{in} \rightarrow F_{out}$) and with a heated outer mantle, and that the outer face (21') of the mantle (21) of the centre roll (20;20A) is heated by means of said circulation of medium ($F_{in} \rightarrow F_{out}$) to such a temperature level (T_S) that the dewatering of the paper web (W) in the nips (N_2,NP_1;N_2,NP_{11}) placed in connection with the centre roll (20;20A), in particular in said extended nip (NP_1;NP_{11}), is intensified substantially.

2. A press section as claimed in claim 1, **characterized** in that in connection with said centre roll (20) there is first a sharp and short roll nip (N_2), through which the first water-receiving press felt (12) in the press section is passed, which felt also operates as a pick-up felt, on which the web (W) is transferred from the forming wire (10) to the press section, and that the last press zone in connection with the centre roll (20) is said extended nip (NP_1;NP_{11}), through which a water-receiving press felt (32) is passed, which operates as the second upper fabric in the press section.

3. A press section as claimed in claim 1 or 2, **characterized** in that the centre roll (20) is a roll provided with means (26,27,28) for producing a loading force and/or crown variation and further preferably provided with arrangements for regulation of the cross-direction compression pressure profile in said extended-nip zone.

4. A press section as claimed in claim 3, **characterized** in that in said heated centre roll (20) there are means (26a) for regulation of the loading force and/or of the deflection also placed facing the first roll nip (N_2) which has been formed in connection with the centre roll (20).

5. A press section as claimed in any of the claims 1 to 4, **characterized** in that the press includes a press nip separate from the compact combination of rolls, which separate press nip is either a roll nip (N_{20}) or an extended nip (NP_2) and in which nip the smooth-faced upper roll (55;55A) is preferably a heated roll.

6. A press section as claimed in any of the claims 1 to 5, **characterized** in that said centre roll in the press is a roll (20;20A) provided with circulation of a heating medium, the cylinder mantle (21;210) of said roll being provided with a number of axial ducts (22;220) for the flow of the heating medium, which ducts are interconnected in pairs (22',22";220',220") through end ducts (22b;227), and that said ducts are connected to a heating-medium flow coupling (25;250) placed at the opposite end of the heated roll (20;20A), the end of the heated roll (20;20A) opposite to the end with said flow coupling being provided with mechanical drive gears (70,71,72,73) of the roll.

7. A press section as claimed in any of the claims 1 to 6, **characterized** in that, in connection with said centre roll (20;20A), there are additional heating devices which raise the temperature level (T_S) at the outer face (21') of the roll mantle (21), such as hot-water jets (19), which are preferably placed in connection with the doctor or doctors (18) of the centre roll (20;20A), a steam box (17), and/or an equivalent infrared heater, which is preferably fitted between the first roll nip (N_2) placed in connection with the centre roll (20;20A) and the following extended nip (NP_1,NP_{11}).

8. A press section as claimed in any of the claims 1 to 7, **characterized** in that the temperature of the outer face (21') of the mantle (21) of the centre roll (20;20A) has been raised by means of said circulation of medium ($F_{in} \rightarrow F_{out}$) to the level TS $\approx$

60...95°C and/or that the temperature level of the heating medium in said circulation of medium ($F_{in} \rightarrow F_{out}$) has been arranged in the range of $T_f \approx 70...180°C$.

9. A press section as claimed in any of the claims 1 to 8, **characterized** in that, before the first or second roll nip (N_2) connected with the heated centre roll (20) in the press section, the first nip in the press section is a separate press nip, preferably an extended nip (NP_{10}), whose upper fabric is a pick-up felt (12A) (Fig. 6).

10. A press section in a paper machine, which press section comprises two or more separate press nips (NP_{12},NP_{22}), of which nips at least the last nip is an extended nip (NP_{22}), and between which press nips the paper web (W) has a closed draw supported by a roll face or a press fabric (12A,15B,65), **characterized** in that the press roll in the last extended nip (NP_{22}) is a press roll (20B) provided with circulation of heating medium ($F_{in} \rightarrow F_{out}$) and with a heated outer mantle, and that the outer face (21') of the mantle (21) of said press roll (20B) is heated by means of said circulation of medium ($F_{in} \rightarrow F_{out}$) to such a temperature level (T_S) that the dewatering of the paper web (W) is intensified substantially in the extended nip (NP_{22}) placed in connection with said press roll (20B) (Figs. 7 and 7A).

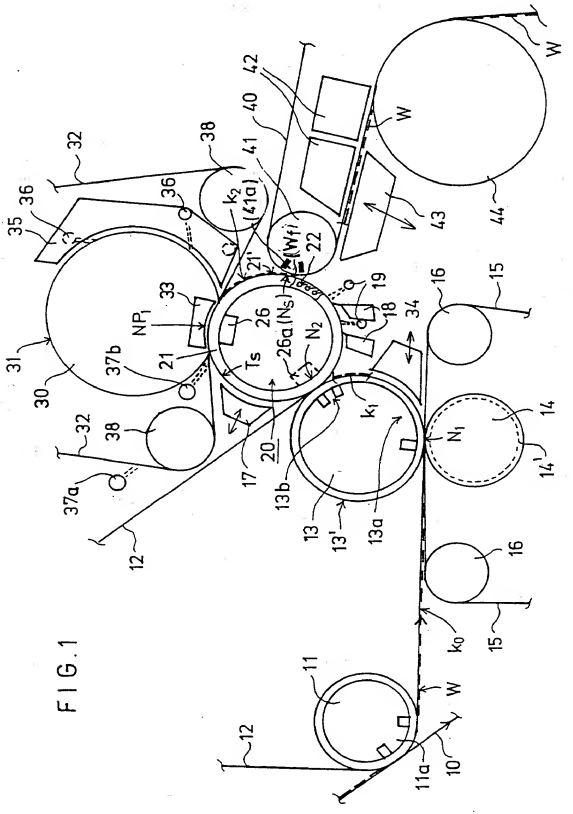
11. A press section as claimed in claim 10, **characterized** in that, before the last extended nip (NP_{22}), in connection with said heated press roll (20B), there is a pre-roll nip (N_{02}) (Fig. 7A).

12. A press section as claimed in claim 10 or 11, **characterized** in that, in the first nip in the press section, which is preferably an extended nip (NP_{12}), the upper fabric (12A) is a pick-up fabric, which brings the web (W) from the forming wire (10) into the first press nip (NP_{12}), and that in said first press nip (NP_{12}) the lower fabric (15B) is a press felt or an equivalent transfer belt, which carries the web (W) onto the upper fabric (65) of the extended nip (NP_{22}) following after the first nip (NP_{12}), which upper fabric (65) is preferably a press felt, which operates as the upper fabric in the latter extended nip (NP_{22}), which nip is, for its part, formed by said heated press roll (20B) (Fig. 7).

13. A press section as claimed in any of the claims 10 to 12, **characterized** in that said heated press roll (20B) is a press roll provided with circulation of heating medium, as claimed in any of the claims 3, 4 or 6.

14. A press section as claimed in any of the claims 1 to 13, **characterized** in that the surface temperature T_S of said centre roll (20) or equivalent press roll (20B) has been chosen so or arranged to be regulated so that the separation of the web from said centre roll or equivalent press roll is facilitated.

15. A press section as claimed in any of the claims 1 to 14, **characterized** in that, in connection with said heated centre roll (20) or with the heated press roll (20B), a transfer nip (N_S) formed by a transfer suction roll (41,41a) has been arranged.


W
42
40
41
38
32
36
35
36
k_2
(41a)
(Wf)
22
21'
43
44
19
16
15
33
NP_1
26
N_s
N_2
18
34
31
37b
21
Ts
26a
30
32
38
k_1
N_1
14
14'
37a
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15
k_0
W
11
12
11a
10

FIG. 1

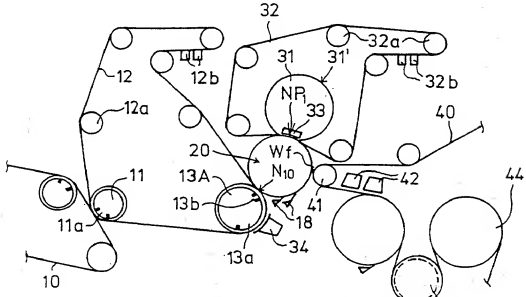

32
32a
31
31'
12
12b
32b
NP1
33
12a
40
20
Wf
N10
11
13A
42
44
13b
41
11a
18
34
13a
10
45'
45

FIG. 2

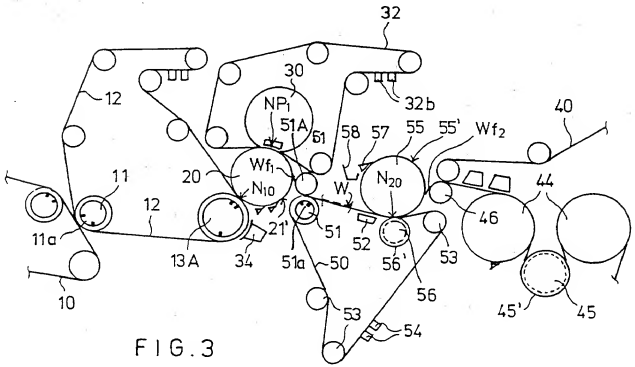

32
30
12
32b
NP1
51A
61
58
57
55
55'
Wf2
40
Wf1
20
N10
N20
11
W2
44
12
46
11a
21'
51
52
13A
34
51a
50
56'
53
10
56
45'
45
53
54

FIG. 3

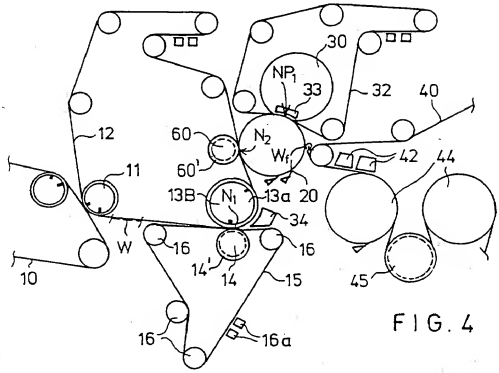

30
NP1
33
32
40
12
60
N2
Wf1
42
44
11
60'
13B
N1
13a
20
34
W
16
16
14'
14
15
45
10
16
16a

FIG. 4

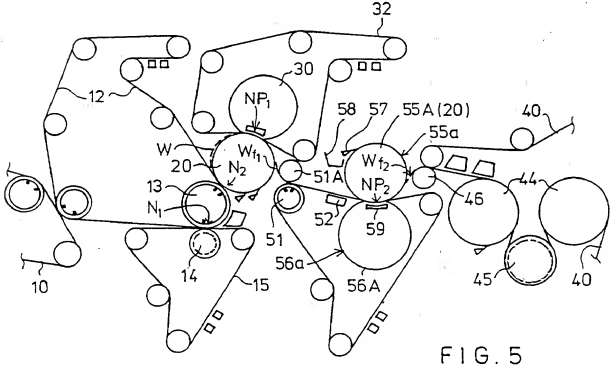

32
30
12
NP1
58
57
55A(20)
40
55a
W
20
N2
Wf1
51A
Wf2
NP2
13
N1
46
44
52
59
51
14
56a
56A
45
40
10
15

FIG. 5

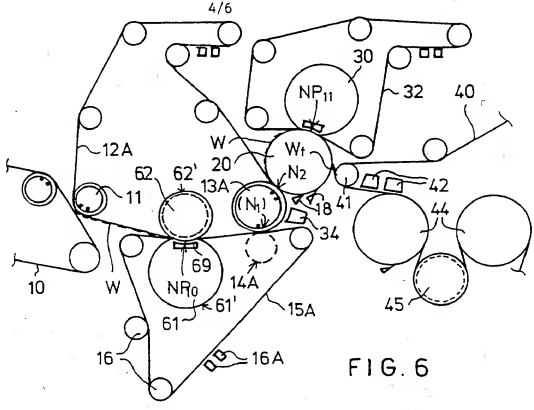


FIG. 6

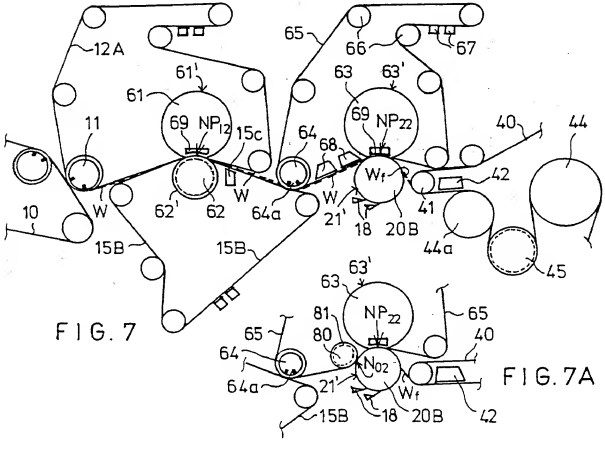
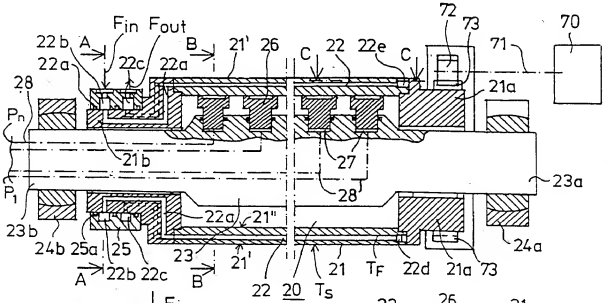


FIG. 7

FIG. 7A

FIG. 8



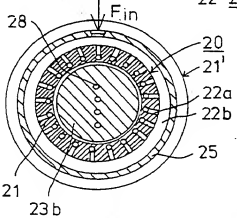


FIG. 8A

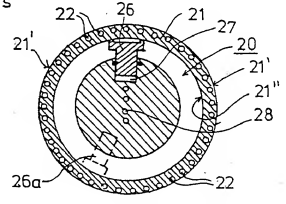


FIG. 8B

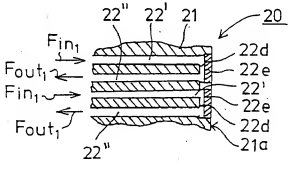
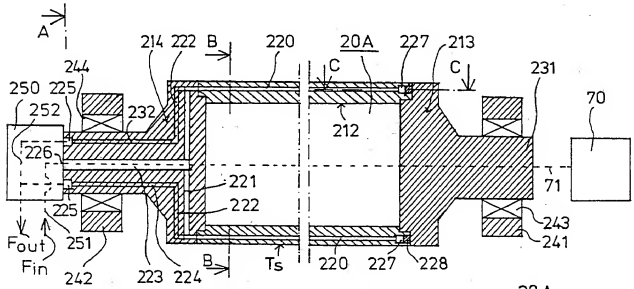


FIG. 8C

FIG. 9



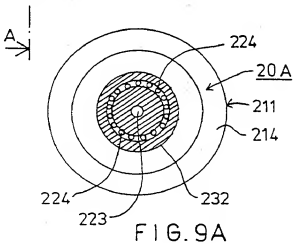


FIG. 9A

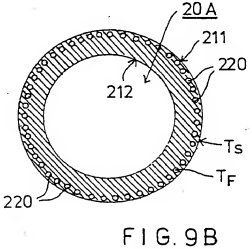


FIG. 9B

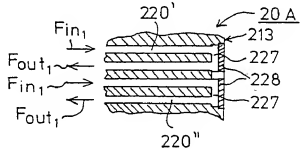


FIG. 9C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 96/00542

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21F 3/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0549553 A1 (VALMET PAPER MACHINERY INC.), 30 June 1993 (30.06.93) -- ---	1,10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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